



APPLICATION NO. 09/846,410

TITLE OF INVENTION: Multiple Data Rate Hybrid Walsh Codes for  
CDMA

INVENTOR: Urbain A. von der Embse

Clean version of how the CLAIMS will read.



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## CLAIMS

WHAT IS CLAIMED IS:

- 10        Claim 1. (cancelled)  
         Claim 2. (cancelled)  
         Claim 3. (cancelled)  
         Claim 4. (cancelled)

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Claim 5. (currently amended) A method for generating and  
applying hybrid Walsh complex orthogonal codes for code division  
multiple access (CDMA), said method comprising the steps:

- generating N Walsh codes  $W(c)$  with code index  $c=0,1,2,\dots,N-1$ ,  
20        each with N chips where N is a power of 2,

         generating said N hybrid Walsh codes  $\tilde{W}(c)$  by reordering each of  
said N Walsh codes into a corresponding real component and  
a corresponding imaginary component of a hybrid Walsh code  
as defined by equations

- 25        for  $c = 0$ ,                     $\tilde{W}(c) = W(0) + jW(0)$   
         for  $c = 1,2,\dots,N/2-1$ ,        $\tilde{W}(c) = W(2c) + jW(2c-1)$   
         for  $c = N/2$ ,                  $\tilde{W}(c) = W(N-1) + jW(N-1)$   
         for  $c = N/2+1,\dots,N-1$ ,      $\tilde{W}(c) = W(2N-2c-1) + jW(2N-2c)$

         wherein  $j=\sqrt{-1}$ ,

- 30        wherein said hybrid Walsh codes are generated by reading the N  
Walsh codes chip values from a Walsh code memory in a  
digital signal processor and writing to a hybrid Walsh code

memory using addresses specified by said reorderings of  
said N Walsh codes,  
applying said hybrid Walsh codes in an encoder and in a decoder  
of a CDMA system by replacing existing said N Walsh real  
5 codes with said hybrid Walsh complex codes according to a  
same code vector indexing, and  
transmitting data encoded by the encoder and receiving data  
decoded by the decoder.

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Claim 6. (currently amended) A method for generating and  
applying spreading codes for code division multiple access  
(CDMA), comprising the steps:

constructing a spreading code from a hybrid Walsh code and a  
15 a Discrete Fourier Transform (DFT) code,  
said spreading code is defined by an N\*P row by N\*P column  
code matrix C wherein row vectors are code vectors and  
column elements are code chips,  
said hybrid Walsh code is defined by a N row by N column  
20 code matrix  $\tilde{W}$ ,  
said DFT code is defined by a P row by P column code matrix  
E,

said spreading code matrix C is constructed by a Kronecker  
product of said hybrid Walsh code matrix  $\tilde{W}$  with said DFT  
25 code matrix E defined by the equation

$$C = \tilde{W} \otimes E$$

wherein the operator " $\otimes$ " is a Kronecker product operation,  
applying said spreading code matrix C in an encoder and in a  
decoder of a CDMA system by replacing existing said N Walsh  
30 real codes with said hybrid Walsh complex codes according  
to a same code vector indexing, and  
transmitting data encoded by the encoder and receiving data  
decoded by the decoder.

Claim 7. (currently amended) A method for implementing hybrid Walsh codes for CDMA, comprising the steps:

encoding N data symbols contained in a block with respective N

5        hybrid Walsh codes to yield N encoded data symbols for each block at the output chip rate of  $1/T$  chips per second wherein T is the interval between chips,

wherein said encoder accepts up to N users per block wherein N

10        is a power of 2 and M is the actual number of users represented in the block, each of said users having a data rate corresponding to one of  $1, 2, \dots, N/2$  data symbols per block,

wherein said encoder accepts packets from each user and writes

15        them to memory "A" for each block, wherein a binary address index comprising a number of bits corresponding to the maximum number of users N is used for addressing said data symbols stored in memory "A" and the data symbols for each user of the block are stored in memory "A" in a hierarchy such that a particular user is selected according to a  
20        number of more significant bits of the binary address index and the data symbols of the particular user are selected according to a number of lesser significant bits of the binary address index, the number of more significant bits and lesser significant bits of the particular user being  
25        determined according to the data rate of the particular user and the total number of users M per block.

Claim 8. (currently amended) Wherein said hybrid Walsh  
30        codes in claim 5 have a fast encoding implementation algorithm, comprising the steps:

wherein said fast encoding algorithm implemented in the encoder uses memory "A" for input and to support pass 1 and uses memories "B", "C" to support passes  $2, \dots, M$  wherein  $N=2^M$

and uses memory "D" to store the encoded chip output from the reordering pass,

writing input data symbol vector  $Z(d_0, d_1, \dots, d_{M-2}, d_{M-1})$  to said "A" wherein the binary addressing word takes address values

5  $d_0 d_1 \dots d_{M-2} d_{M-1} = 0, 1, 2, \dots, N-1,$

wherein pass 1 reads pairs of data symbols from "A" corresponding to  $d_0=0, 1$  wherein the addresses of the data symbol for  $d_0=0$  are  $0, 2, 4, \dots, N-2$  and for  $d_0=1$  are  $1, 3, \dots, N-1$  and for each pair of data symbols pass 1 performs a 2-point hybrid

10 Walsh transform and sums the outputs for each of the encoded chip binary index values  $n_{M-1}=0, 1$  and writes the outputs to memory "B" using the addresses of the respective data symbols corresponding to  $d_0=0, 1$ , and pass 1 processing generates the data vector  $Z(n_{M-1}, d_1, \dots, d_{M-1})$

15 in "B",

wherein pass  $m=2, 3, \dots, M-1$  reads pairs of data symbols from "B", "C", "B",  $\dots$  and writes the outputs to "C", "B", "C",  $\dots$  and data symbol pairs for  $d_{m-1}=0, 1$  are read over address blocks each of length  $2^m$  and starting with the first

20 address block the data symbol  $d_{m-1}=0$  is read for addresses  $0, 1, \dots, 2^{(m-1)}$  and for  $d_{m-1}=1$  the data symbol addresses are  $2^{(m-1)}+1, \dots, 2^m$  and for each pair of data symbols pass  $m$  performs a 2-point hybrid Walsh transform and sums the outputs for each of the encoded chip binary index

25 values  $(n_{M-m+1} \ n_{M-m}=0, 1)$  and writes the outputs to addresses  $(n_{M-m+1}, 0), (n_{M-m+1}, 1)$  corresponding to the addresses of the input  $d_{m-1}=0, 1$  and this processing is repeated for each of the address blocks and pass  $m$  processing generates the data vector  $Z(n_{M-1}, \dots, n_{M-m}, d_m, \dots, d_{M-1}),$

30 wherein pass  $M$  reads pairs of data symbols from "B" or "C" and writes the outputs to "C" or "B" and data symbol pairs for  $d_{M-1}=0, 1$  are read over addresses  $0, 1, \dots, N/2-1$  for  $d_{M-1}=0$  and over addresses  $N/2, \dots, N-1$  for  $d_{M-1}=1$  and for each pair of data symbols pass  $M$  performs a 2-point hybrid Walsh

transform and sums the outputs for each of the encoded chip binary index values  $(n_1, n_0=0,1)$  and writes the outputs to addresses  $(n_1,0)$ ,  $(n_1,1)$  corresponding to the addresses of the input  $d_{M-1}=0,1$  and pass M processing generates the data

5 vector  $Z(n_{M-1}, \dots, n_0)$ ,

wherein a final reordering pass reorders the encoded chip symbols in memory "B" or "C" and stores the ordered output  $Z(n_0, n_1, \dots, n_{M-2}, n_{M-1})$  in memory "D", and

wherein said encoder in said CDMA transmitter reads said encoded

10 chip vector in said "D" and overlays said vector with long and short pseudo-noise (PN) codes to generate N chips of said encoded chip vector for transmission.

15 Claim 9. (currently amended) Wherein said hybrid Walsh codes in claim 5 have a fast decoding implementation algorithm, comprising the steps:

wherein the decoder strips off said pseudo-noise (PN) codes from the received N chip encoded chip vector and writes the

20 resultant encoded chip vector  $Z(n_0, n_1, \dots, n_{M-2}, n_{M-1})$  to memory "A" wherein the binary addressing word takes address values  $n_0 n_1 \dots n_{M-2} n_{M-1} = 0, 1, 2, \dots, N-1$ ,

wherein said fast decoding algorithm implemented in said decoder uses said memory "A" for input and to support pass 1 and

25 memories "B", "C" support passes 2,  $\dots$ , M and memory "D" stores the decoded data symbols from the rescaling and reordering pass,

wherein pass 1 reads pairs of encoded chip symbols from "A" corresponding to  $n_0=0,1$  wherein the addresses of the chip symbols for  $n_0=0$  are 0, 2, 4,  $\dots$ , N-2 and for  $n_0=1$  are 1, 3,  $\dots$ , N-1 and for each pair of chip symbols pass 1 performs a 2-point hybrid Walsh inverse transform and sums the outputs for each of the encoded data symbol index values  $d_{M-1}=0,1$  and

30 writes the outputs to memory "B" using the addresses of the

respective chip symbols corresponding to  $n_0=0,1$  and pass 1 processing generates the vector  $Z(d_{M-1}, n_1, \dots, n_{M-1})$  in "B",

wherein pass  $m=2,3,\dots,M-1$  reads pairs of chip symbols from

5 "B","C","B",... and writes the outputs to "C","B","C",... and chip symbol pairs for  $n_{m-1}=0,1$  are read over address blocks each of length  $2^m$ , and starting with the first address block the chip symbol  $n_{m-1}=0$  is read for addresses  $0,1,\dots,2^{(m-1)}$  and for  $n_{m-1}=1$  the chip symbol addresses are  
10  $2^{(m-1)}+1, \dots, 2^m$  and for each pair of chip symbols pass  $m$  performs a 2-point hybrid Walsh inverse transform and sums the outputs for each of the decoded data symbol binary index values  $(d_{M-m+1}, d_{M-m}=0,1)$  and writes the outputs to addresses  $(d_{M-m+1}, 0), (d_{M-m+1}, 1)$  corresponding to the addresses  
15 of the input  $n_{m-1}=0,1$  and this processing is repeated for each of the address blocks and pass  $m$  processing generates the data vector  $Z(d_{M-1}, \dots, d_{M-m}, n_m, \dots, n_{M-1})$ ,

wherein pass  $M$  reads pairs of chip symbols from "B" or "C" and

20 writes the outputs to "C" or "B" and chip symbol pairs for  $n_{M-1}=0,1$  are read over addresses  $0,1,\dots,N/2-1$  for  $n_{M-1}=0$  and over addresses  $N/2,\dots,N-1$  for  $n_{M-1}=1$  and for each pair of chip symbols pass  $M$  performs a 2-point hybrid Walsh inverse transform and sums the outputs for each of the decoded data symbol binary index values  $(d_0, d_1=0,1)$  and  
25 writes the outputs to addresses  $(d_1, 0), (d_1, 1)$  corresponding to the addresses of the input  $n_{M-1}=0,1$ , and pass  $M$  processing generates the data symbol vector  $Z(d_{M-1}, \dots, d_0)$ ,

wherein a final pass scales the decoded data symbols by the  $N$  chip hybrid Walsh inverse transform scaling factor  
30 "1/2N" and reorders the scaled encoded data symbols in memory "B" or "C" and stores the ordered output  $Z(d_0, d_1, \dots, d_{M-2}, d_{M-1})$  in memory "D", and

wherein said decoder in said CDMA receiver reads said decoded data symbol vector in said "D" for further processing to  
35 recover information from the data symbols.